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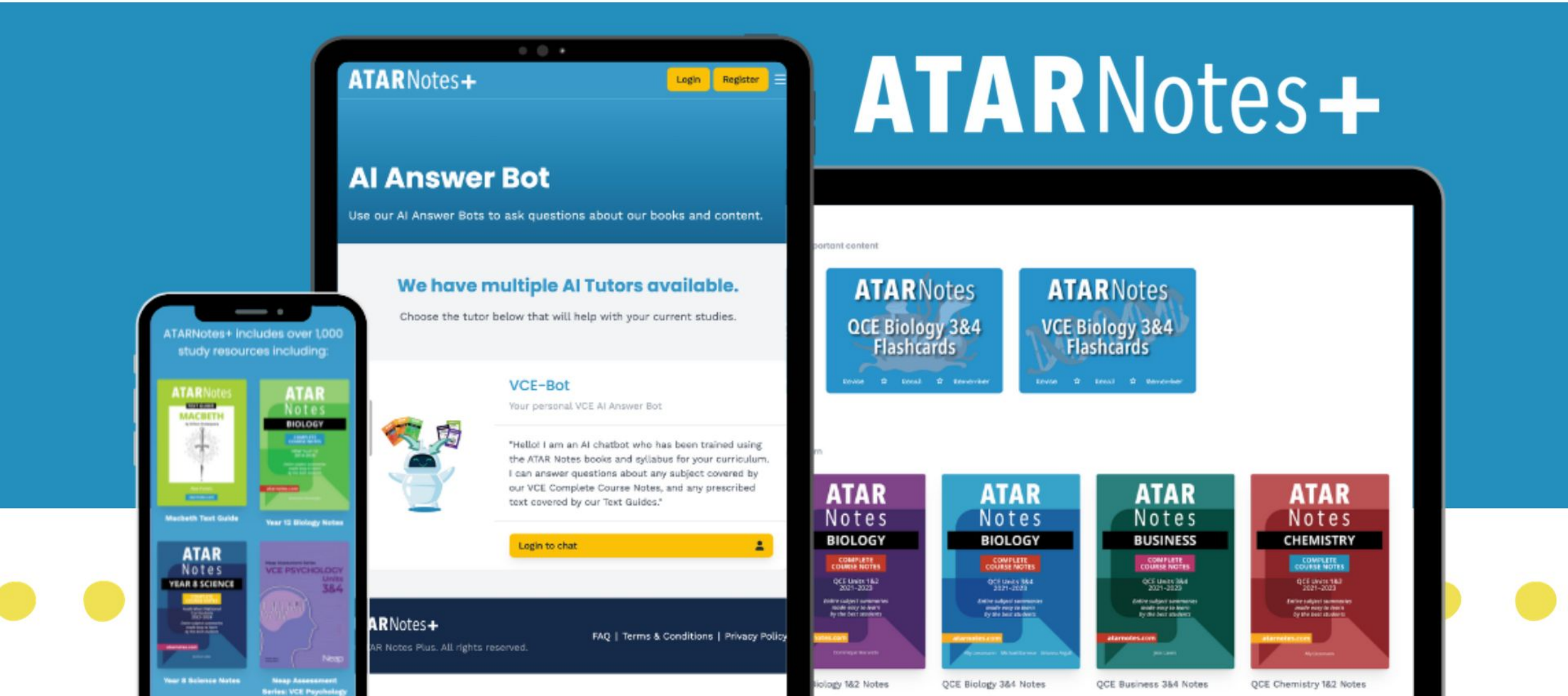

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Year 9 Science

ATARNotes January Lecture Series

Presented by:
Michelle W

How to do well

- Experiment with study strategies *before* there is a lot of pressure
- Maintain balance with things outside of school
- Take care of your general health – physically, emotionally, socially etc. (SLEEP is important)

Year 9 Science Lecture

Topics to be covered

- **Biological and chemical sciences (content block 1)**

1. Biology: Interactions within and between organisms
2. Chemistry: Atoms and chemical reactions

- **Physical and Earth and space sciences (content block 2)**

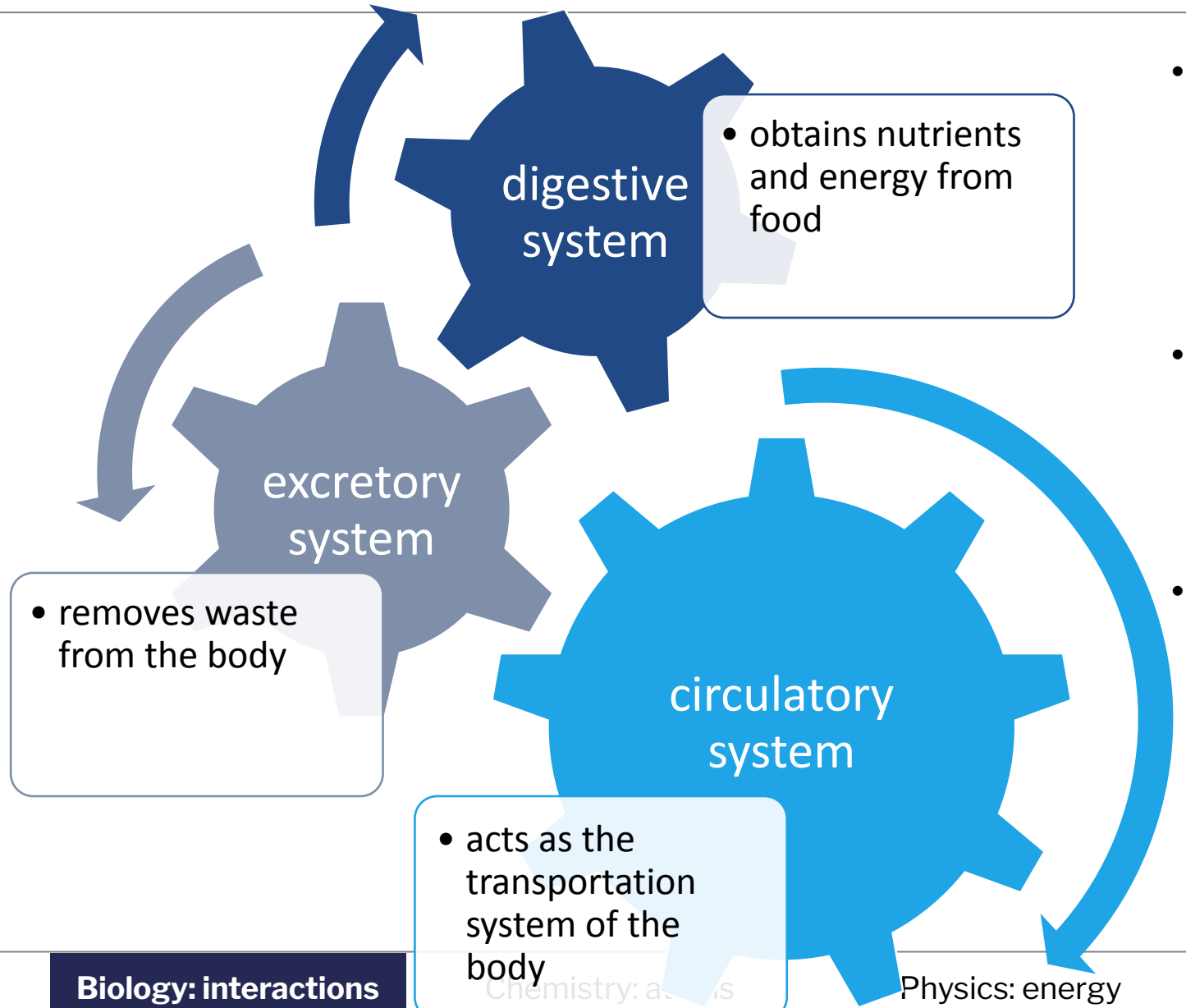
1. Physical sciences: Energy transfer: Particles and waves
2. Earth and space sciences: Tectonic plates

Announcements

- You can download the pdf version of the slides now!
- We'll go for an hour
- Ask any questions via the online chat

Biology: interactions

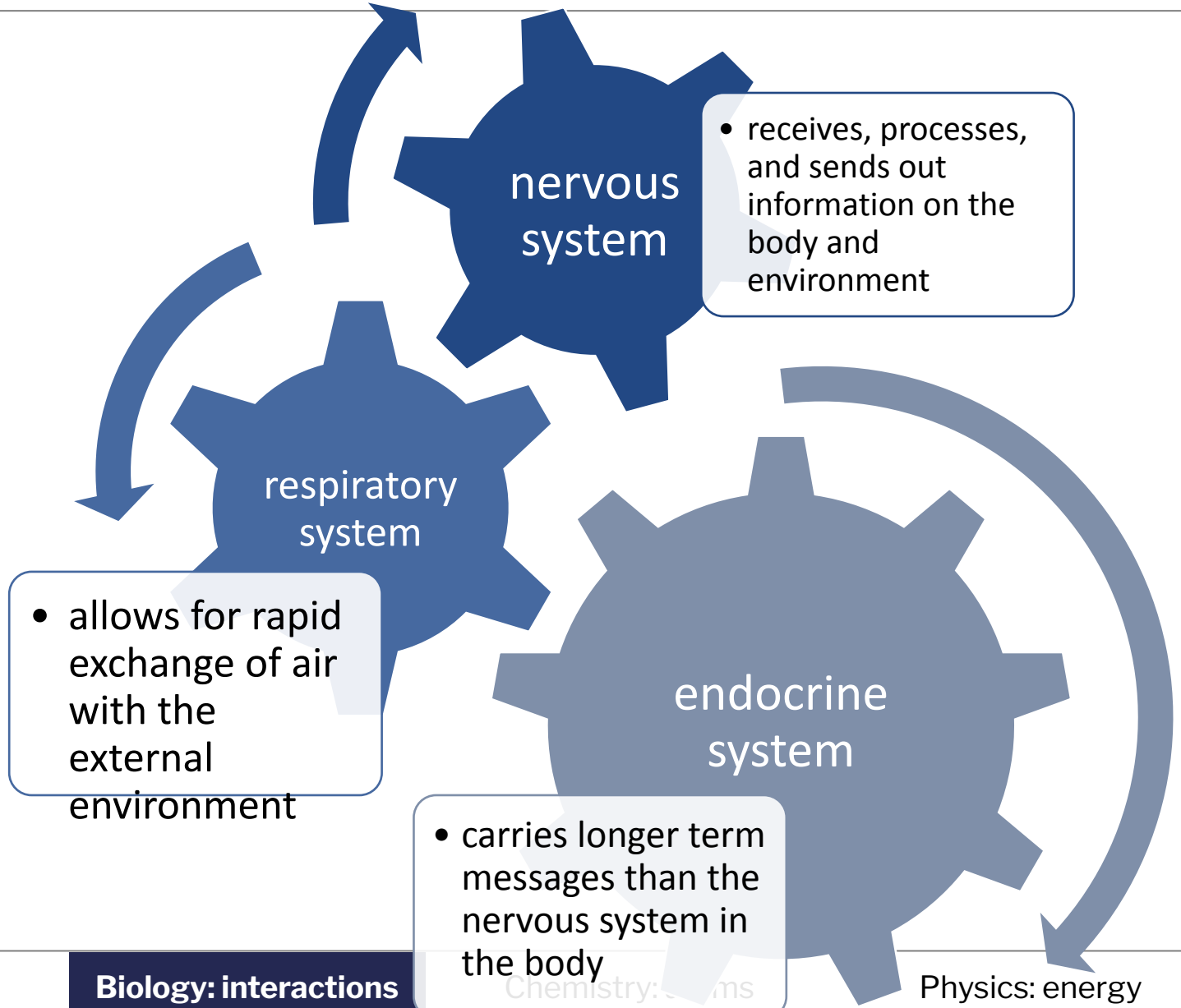
Systems



- Each system within the body is made up of a group of organs which work together to fulfill their functions
- The systems need to work together to function and sustain life
- What other systems within the body can you think of?

Biology: interactions

Systems



For example, in times of stress the nervous system will signal for release of adrenaline into the bloodstream (endocrine), resulting in faster breathing (respiratory system)

Nervous system

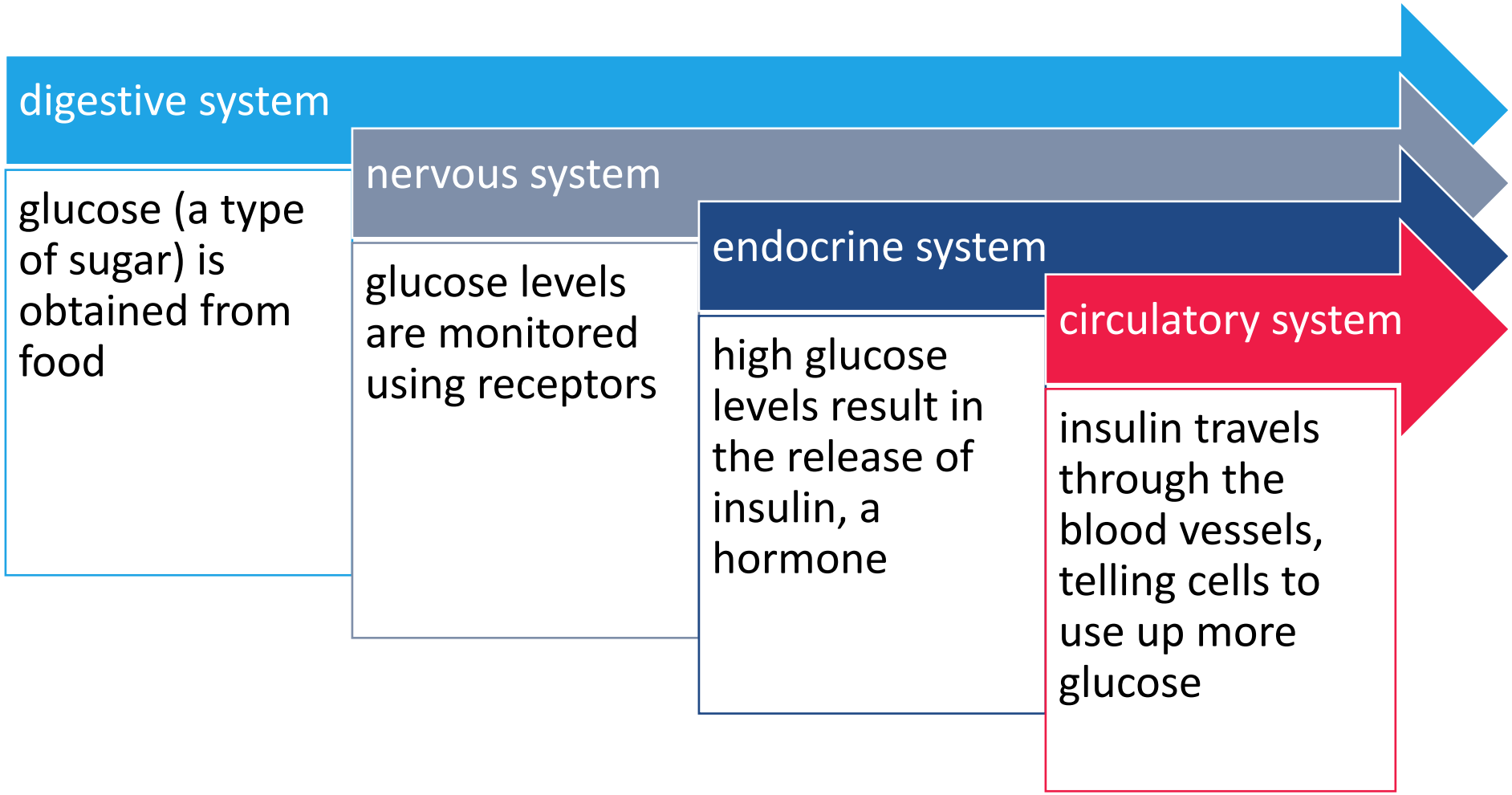
- The nervous system includes the brain and spinal cord which are decision makers in the nervous system
- It also includes other nervous system divisions responsible for obtaining information and/or sending out a message to respond in a particular way.
- All of these rely on neurons – a type of cell
- Communication between neurons is extremely fast and uses neurotransmitters (e.g. dopamine, acetylcholine, GABA)
- Some neurotransmitters can also act as hormones

Endocrine system

- The endocrine system relies on hormones as chemical messengers
- Hormones can be released from glands around the body and/or from neurons
- Hormones travel to other cells nearby or can travel far through the body using the circulatory system.
- When hormones are used as a messenger instead of neurotransmission, the message tends to be received more slowly and acted on for longer

Biology: interactions

Process example

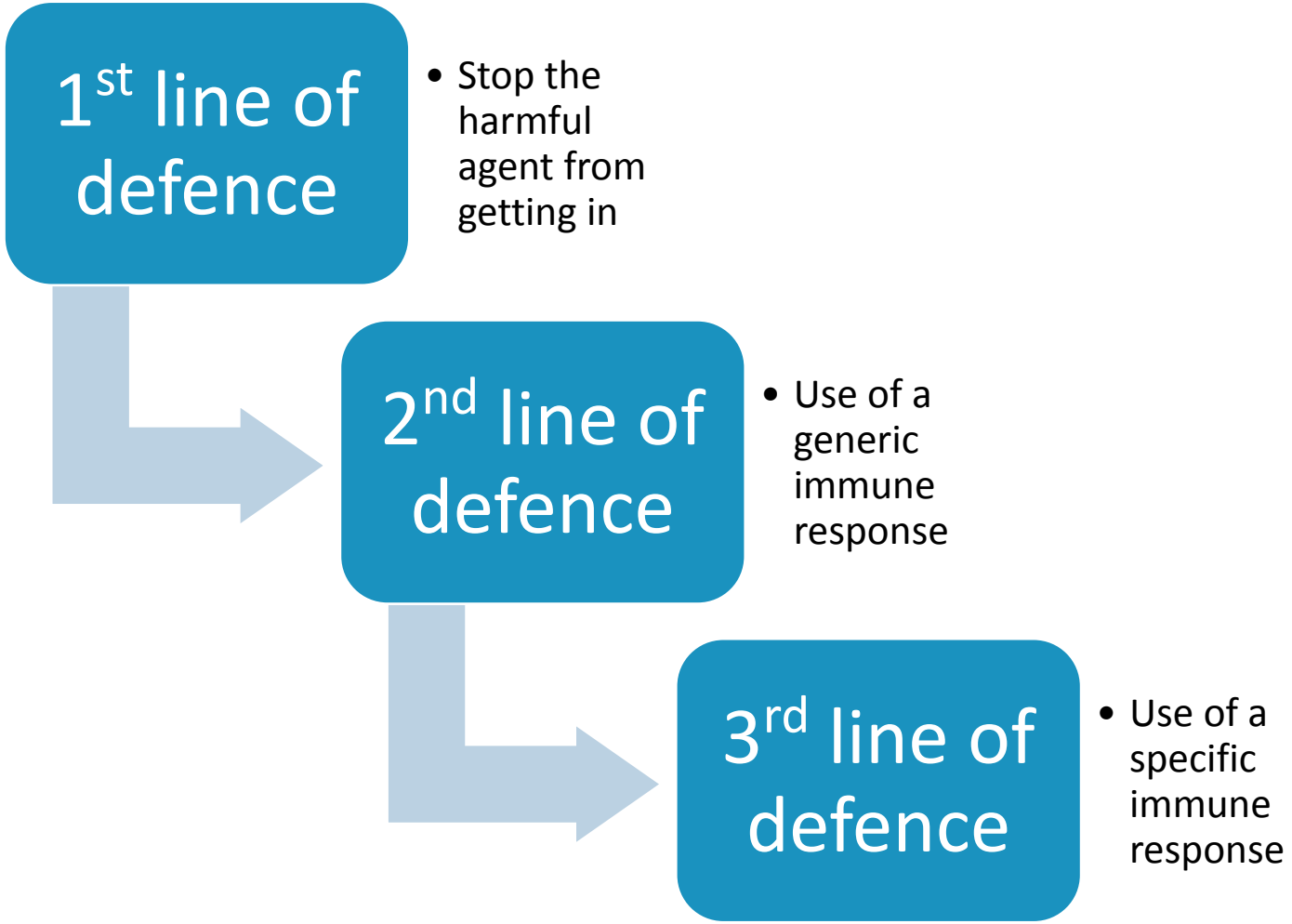


Biology: interactions

Immune system

- What about threats from disease-causing agents?
- The immune system is responsible for protecting us from diseases caused by harmful microorganisms
- However, some microorganisms are beneficial (e.g. commensal bacteria)
- The immune system needs to check whether something is potentially a threat

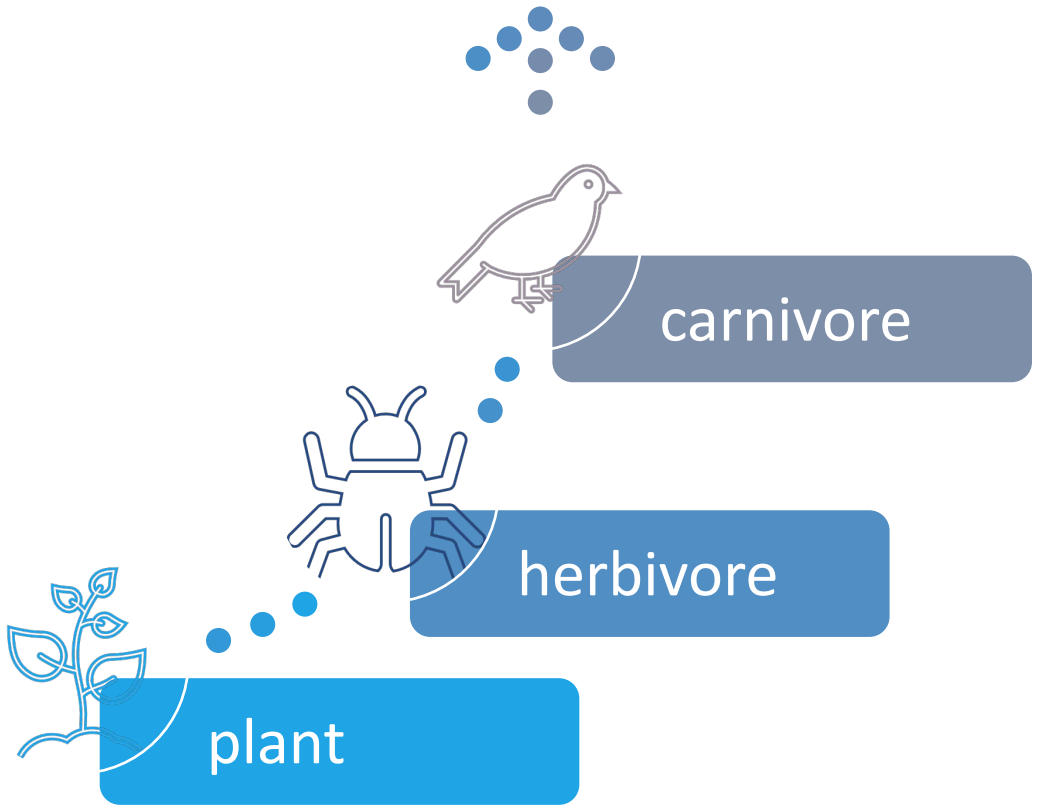
Immunity



- The immune system tries to prevent harmful things from entering us with barriers like intact skin or acidic environments
- Once that has been breached, there may be an inflammatory response as part of the 2nd line of defence
- The third line of defence allows us to remember specific harmful microorganisms and have a strong, fast response in future

Biology: interactions

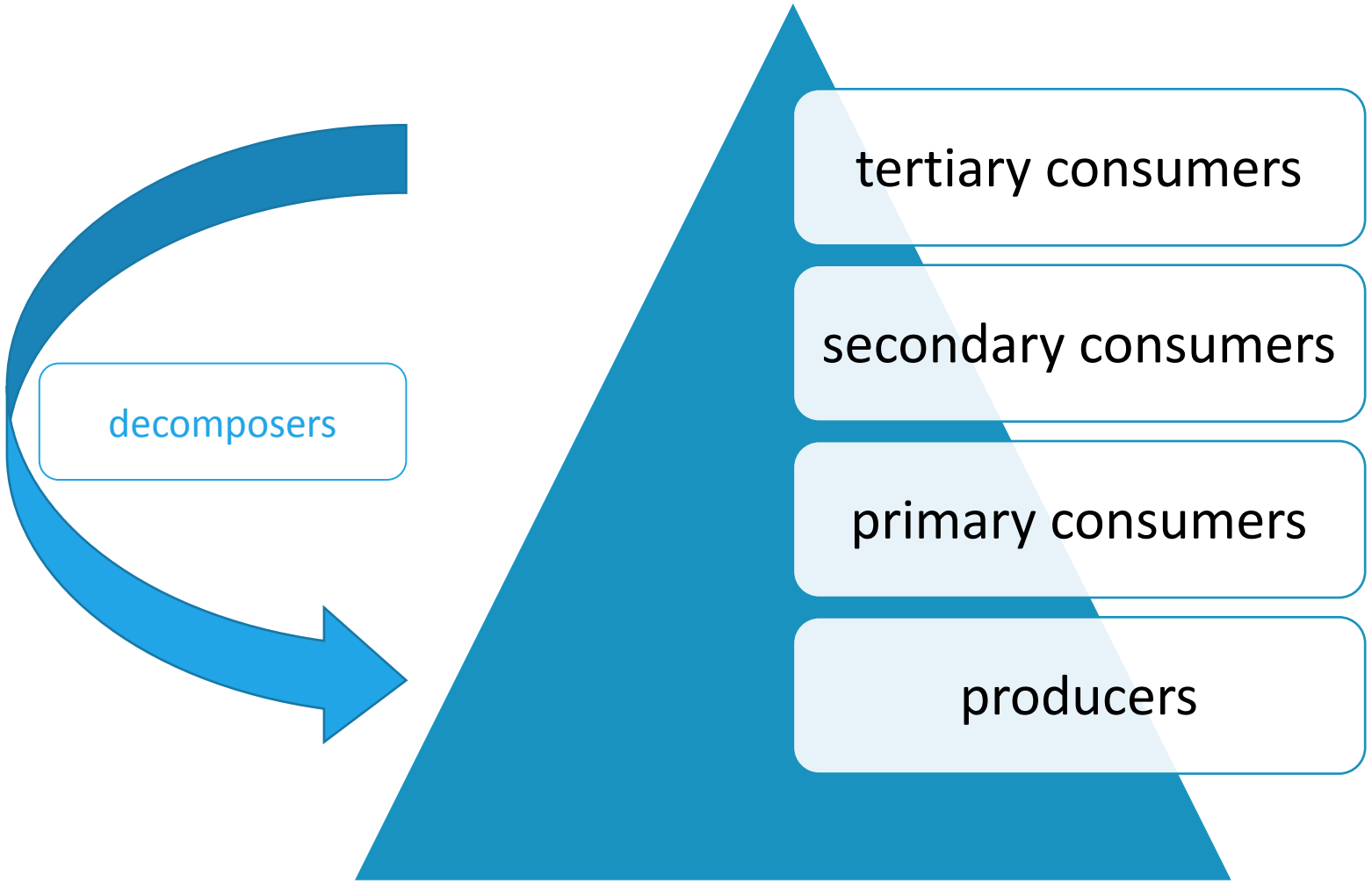
food chains



- Often people think about trophic interactions in terms of food chains
  - An example of this is shown to the left
- A producer is always at the base of the food chain
- Plants are producers and animals are not
- Other organisms, such as photosynthetic bacteria, can also be producers
- Sometimes trophic interactions are depicted by webs – organisms often consume members of more than one species

Biology: interactions

Trophic levels



Biology: interactions

Long-term close association

- The previous interactions we've looked at have been short term
- However, there are also interactions that occur long-term

- mutualism: both organisms benefit
- commensalism: one organism benefits, minimal impact on other
- parasitism: one organism benefits, other is adversely impacted

Biology: interactions

More interactions!

- Other biotic interactions include:

- host with pathogen (disease-causing agent)
- cooperation
  - altruism: acting to benefit another at cost to oneself
- competition

Biotic and abiotic

Biotic

- Living
- e.g. animals, plants, fungi, bacteria

Abiotic

- Non-living
- e.g. temperature, rainfall, geography

Biology: interactions

Example: Budj Bim eel traps

- Budj Bim is a dormant volcano on Gunditjmara Country
- Oral history describes eruption of Budj Bim
- The resulting geography was used built upon and manipulated to (e.g. via creation of dams) to creative an extensive eel trap system
- This example of aquaculture demonstrates interrelationships between humans and natural environments, including land management practices by Aboriginal peoples on Country

Chemistry: atoms

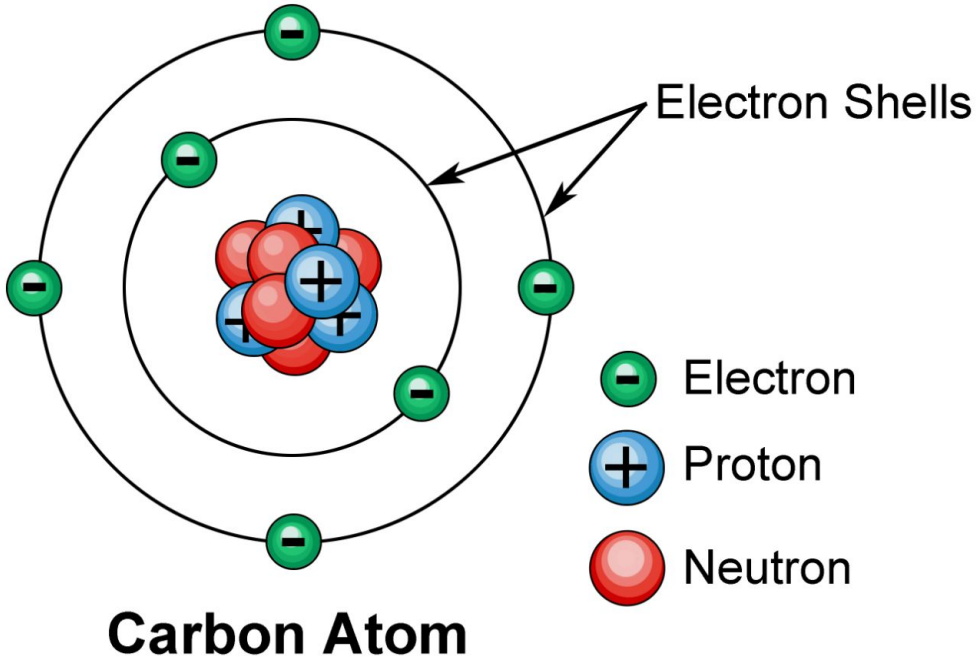
Dating example

- The Budj Bim cultural landscape has been actively managed including repairs – how can we know where different aspects date from?
- One way of investigating this is through radioisotope dating
- Using this technique, carbon dating showed that a piece of charcoal from the traps was more than 6,000 years old
- Tower Hill about 40 km south was also an active volcano, and – like Budj Bim - erupted more than 30,000 years ago (probably closer to 40,000) based on radioisotope dating techniques
- An axe was discovered buried under the volcanic sediments from Tower Hill

- So how does radioisotope dating work?
  First, we need to understand some other concepts

- Matter is made up of atoms, and atoms are classified into elements based on their number of

- Electrons orbit around the nucleus, which contains protons and neutro



Subatomic particles

- Protons are MUCH bigger than electrons, but they have the same charge, so a neutral atom has the same number of protons and electrons
- Neutrons are about as big as protons but are neutral in charge

- For a small element (not many protons) to be stable, there should be about as many neutrons as protons
- If this ratio is too far off, the atom will be unstable, and release radiation to become more stable

- An atom might become more stable by:

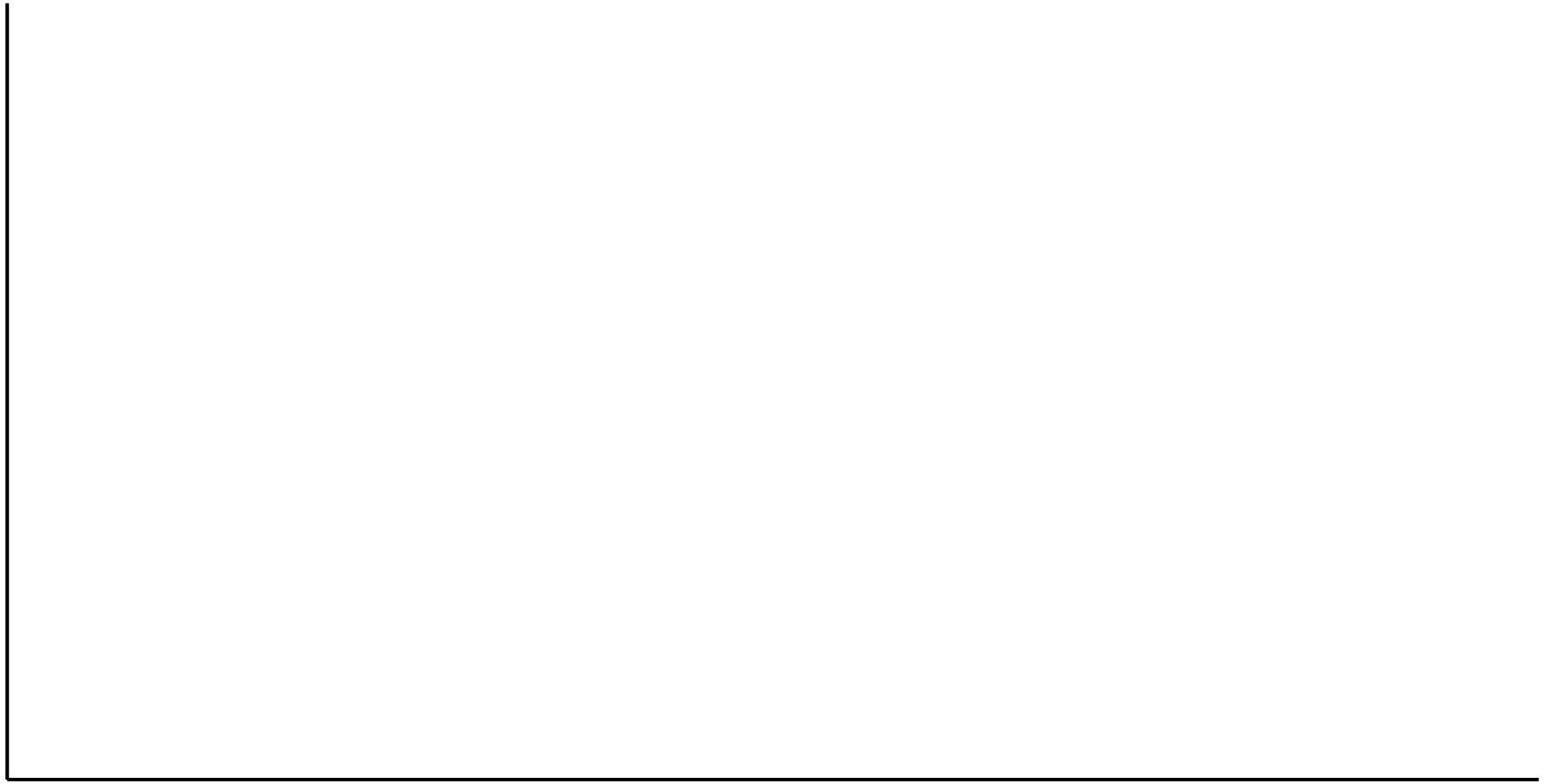
- alpha radiation: ejecting 2 neutrons and 2 protons from the nucleus
- beta radiation: converting a neutron into a proton, releasing an electron
- gamma radiation: releasing energy in the form of light/photons

Chemistry: atoms

carbon dating

- Most carbon atoms are carbon-12 (6 protons + 6 neutrons = 12)
- However, some carbon is carbon-14 (6 protons + 8 neutrons = 14)
- Carbon-14 is unstable, and undergoes beta decay to form nitrogen-14 (7 neutrons + 7 protons = 14)
- It takes 5700 years for half any of carbon-14 sample to decay
- Then it will take another 5700 years to have half of the remaining carbon-14 decay
- Then another 5700 years for the amount of carbon-14 now left to decay
- Thus 5700 years is the half-life of carbon-14

Graphing carbon-14 decay



Chemical reactions

- In chemical reactions, bonds between atoms are broken and/or joined to create new things

- For example:

$$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$$

ethanol and oxygen react to form carbon dioxide and water

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O$$

hydrogen gas reacts with oxygen gas to form water

- Note that the amount of each element is the same on both sides of the equation

Acids

- In high school, we use the Bronsted Lowry definitions of acids and bases

- An acid is a substance which donates protons (or H^+)
  - For example, hydrochloric acid disassociates in hydrogen ions (H^+) and chloride ions (Cl^-): $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
- A base is a substance which accepts/receives protons (or H^+)
  - For example phosphate ions accept hydrogen ions (H^+) to form hydrogen phosphate: $PO^{3-}_{4(aq)} + 3H^+_{(aq)} \rightarrow H_3PO_{4(aq)}$

Combustion reactions

- To write a combustion reaction, have the thing being burnt, add oxygen, and show that water vapour and carbon dioxide are created
- For example, to write butane being combusted:

1. Write the reactants and products: $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
2. Balance the amount of carbon and hydrogen:

$$C_4H_{10} + O_2 \rightarrow 4CO_2 + 5H_2O$$

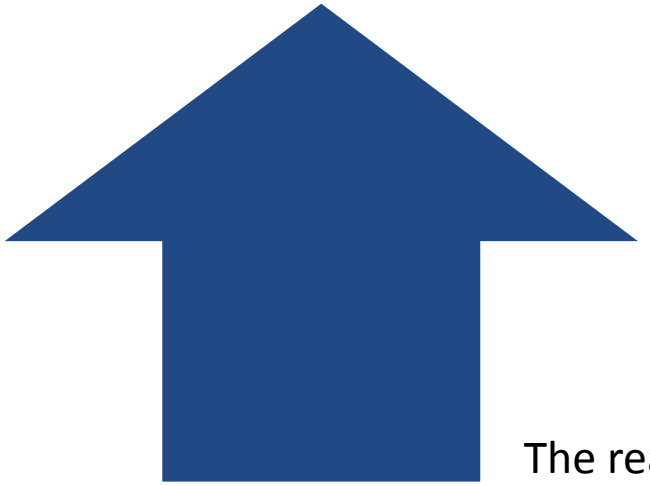
3. Balance the amount of oxygen (double everything to get rid of fractions if required)

$$2C_4H_{10} + 9O_2 \rightarrow 8CO_2 + 10H_2O$$

Enthalpy

- Enthalpy is the difference in the amount of energy innately contained with the reactants, to that innately contained in the products
- This difference will be reflected in energy gained from or released to the surroundings
- Generally, making something more complex from simpler/smaller things requires an energy input
- Conversely, breaking apart a larger substance into simpler ones tends to release energy
- Change in enthalpy is shown as ΔH

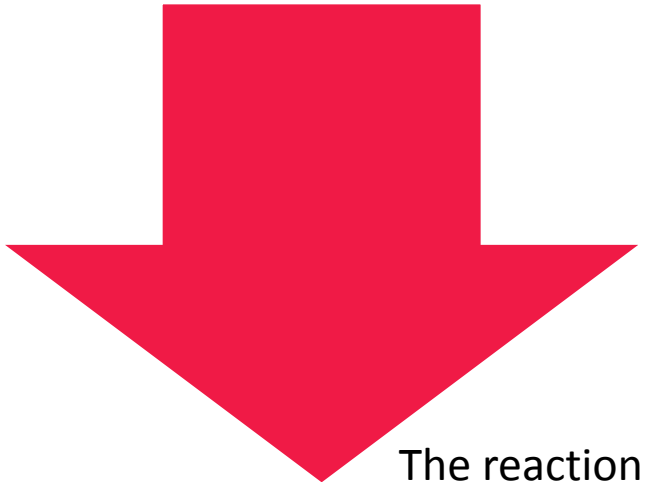
Enthalpy



Endothermic: ΔH>0

in heat energy

The reaction takes energy in from the environment, temperature decreases.



Exothermic: ΔH<0

out heat energy

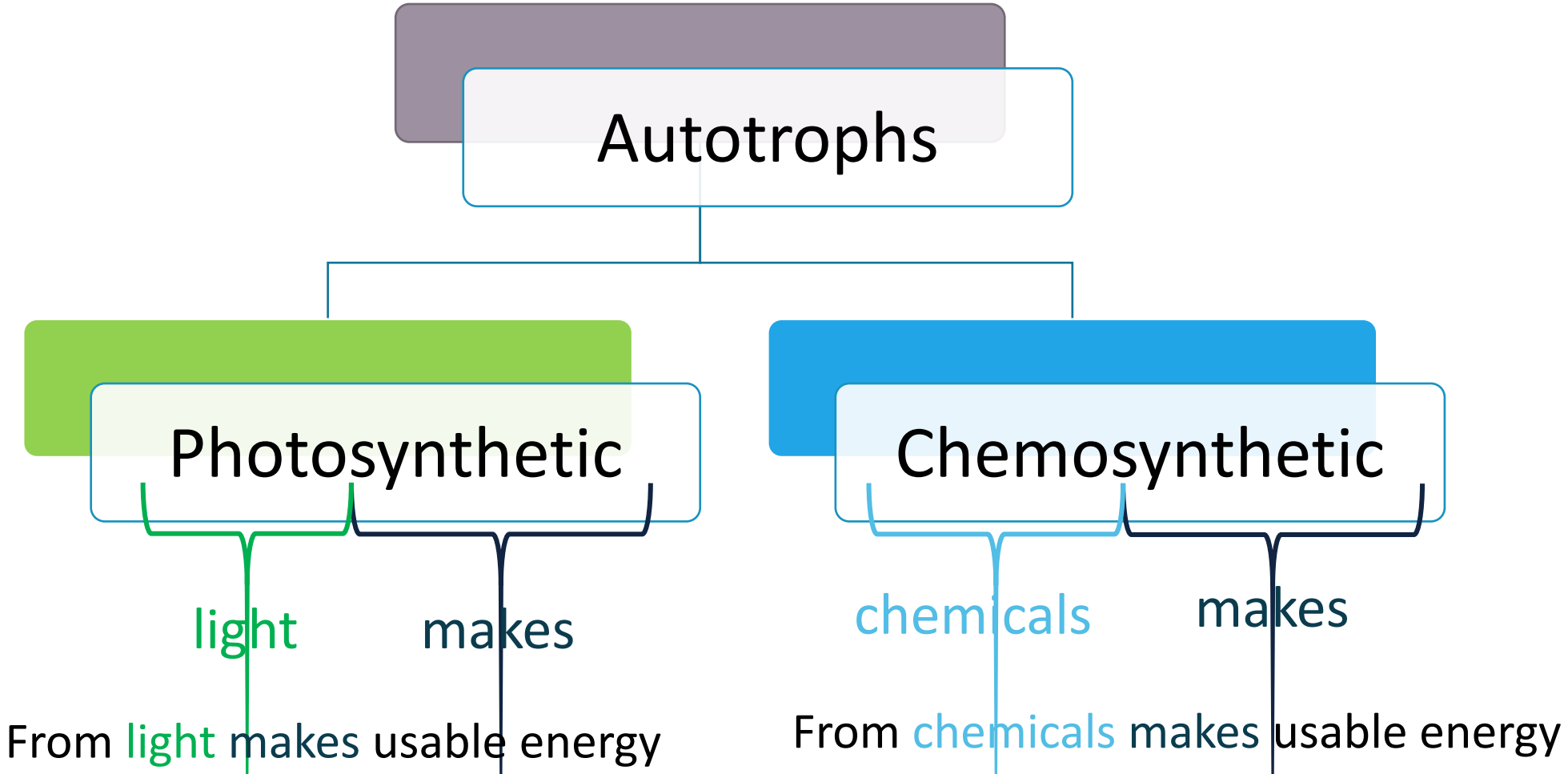
The reaction releases energy out to the environment, temperature increases.

Combustion – environmental impacts

- Greenhouse gases
  - Water is a greenhouse gas – greenhouses gases aren't "evil"
  - However, we have been releasing greenhouses gases faster than they're removed from the atmosphere, and so created imbalance
  - This shift is occurring too quickly for a lot of life to adapt
  - Carbon dioxide and methane are both greenhouses gases that have increased in the atmosphere over recent history
  - Traditional burns, which are low intensity, can be a net positive in terms of carbon emissions

Chemistry: atoms

Reactions producers use



Equations

- The vast majority of producers use photosynthesis rather than chemosynthesis
- Photosynthesis uses energy from light to split water, and ultimately produce glucose

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

- Heterotrophs (consumers) and autotrophs (producers) both use cellular respiration to obtain energy from glucose

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$$

- What do you notice about these equations?

Physics: energy

- Energy can be transferred to different things and transformed into different forms
- For example:
  - kinetic (movement) energy can be transformed into sound energy – such as in instruments
  - electrical energy can be transformed into heat and light energy – such as in lightbulbs

  - We will be focusing on how energy is transferred

Heat

- Objects in contact with each other will try to reach thermal equilibrium by transferring thermal energy (heat)
- e.g. water surrounding an ice cube will transfer heat to the ice

- There are different ways that heat can be transferred:
  - convection
  - conduction
  - radiation

Conductors and insulators

- A conductor readily transfers energy:
  - thermal conductors are great at changing their temperature quickly
  - electrical conductors are great at carrying electricity

- Insulators resist transferring energy:
  - thermal insulators change their temperature slowly
  - electrical insulators resist carrying electricity

- in a wave, energy is transferred without the net (overall) movement of particles

- e.g. a vibrating guitar string moves around a central position (oscillates) and returns to where it originally was
- sound waves move by oscillating particles; the faster the movement, the higher the frequency

Tectonic plates

- Earth's crust is fractured into tectonic plates which can move towards each other, move apart from each other and move against each other
- These movements can result in various effects depending on how and where they occur
- Often, there is a large release of energy in various ways

Earth: tectonics

Tectonic movement

Constructive

- New crust is created
- Think:
  - Long mountain chains
  - Continent break up
  - Underwater eruptions

Destructive

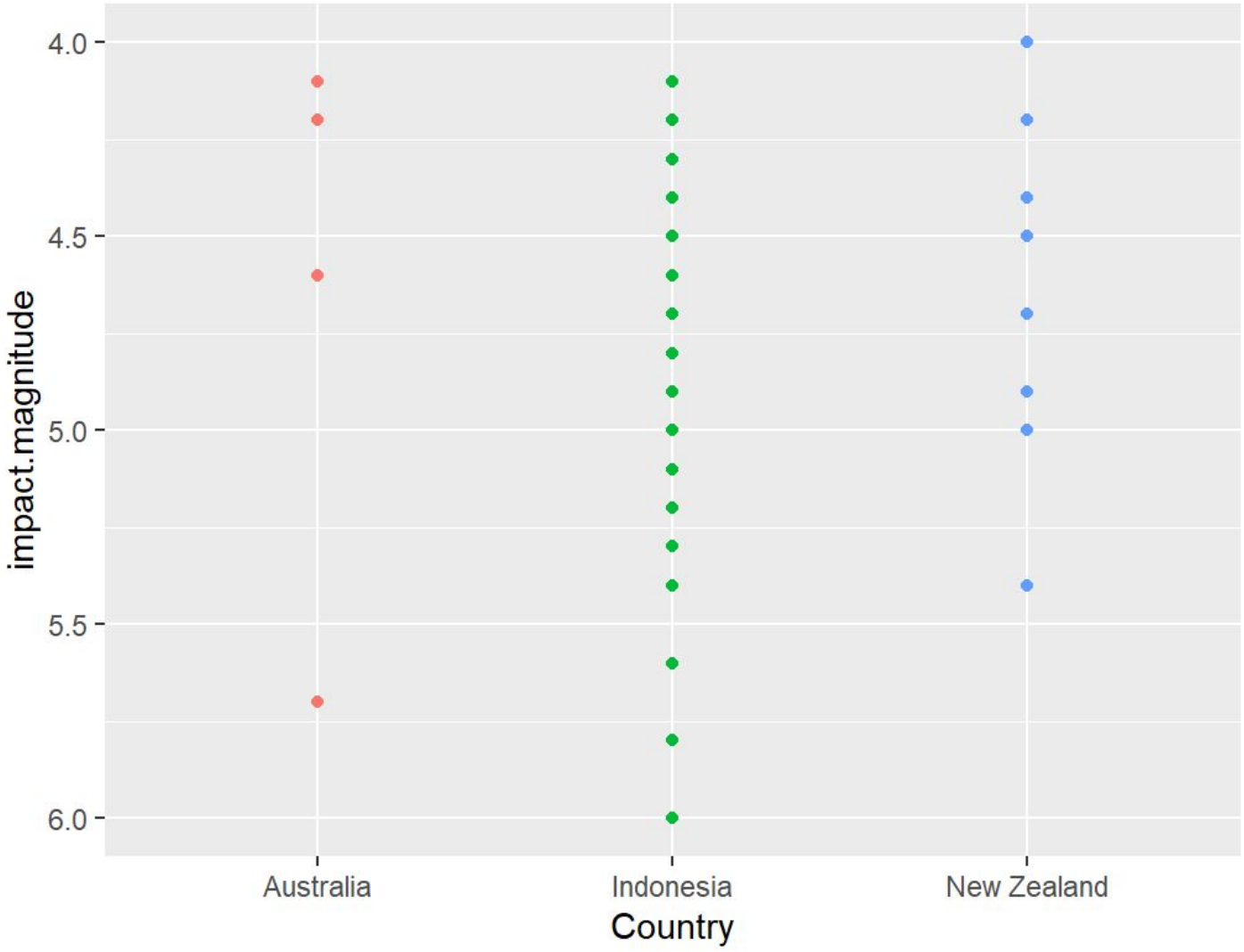
- Crust is destroyed by moving below another plate
- Think:
  - Deep-sea trench formation
  - Fold mountain and volcano formation

Conservative

- Plates slide past each other
- Associated with earthquakes

Earth: tectonics

Data interpretation



How could this graph be improved?

Country
- Australia
- Indonesia
- New Zealand

Data from: https://corgis-edu.github.io/corgis/csv/earthquakes/

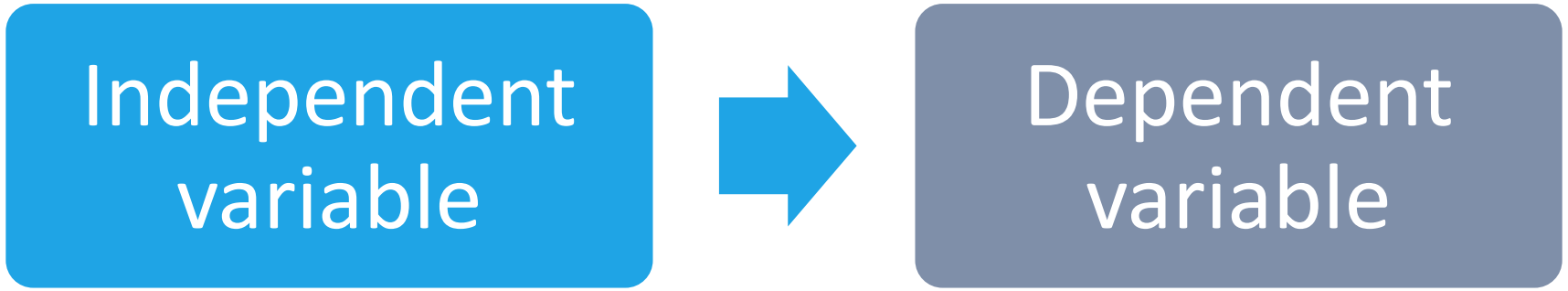
Data manipulation and visualisation using RStudio and R, particularly the ggplot and dplyr packages.

Earth: tectonics

Data explanation

- Australia doesn't experience much tectonic activity because it is in the middle of a plate
- Indonesia is a meeting point for multiple tectonic plates
- New Zealand is situated where two plates meet

- Dependent variable on the y axis
- Independent variable on the x axis
- Clear axis labels (including units!)
- Usually box plots or line graphs will be best



Investigating quality

- Accuracy: Is this the value we measured close to the true one?
- Precision: Is our range of uncertainty around the value small?
- Reliability: Will other experiments measuring this get similar results?
- Validity: Does the data reflect the relationship we think it does? Is this true outside of the specific research context?

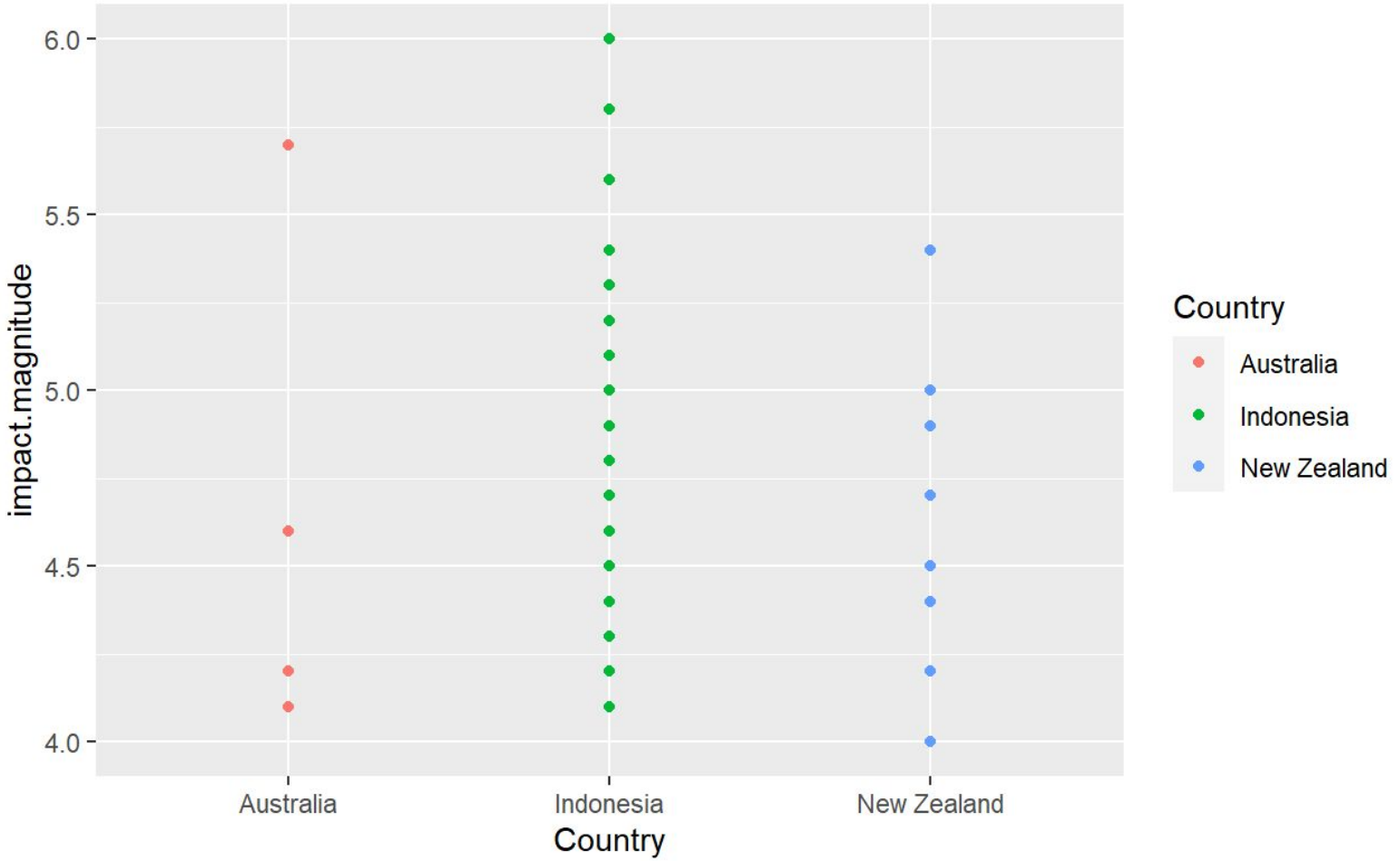
How do you know what data to collect?

Hypotheses

- A hypothesis is a testable statement of the relationship between variables
- E.g. “Year 9 students who experience at least 8 hours of sleep the previous night will obtain higher scores on an IQ test than with fewer than 8 hours sleep.”
- Your opinion is not a statement you will be testing in data collection e.g. “I predict....” “I think...” -> not true hypotheses

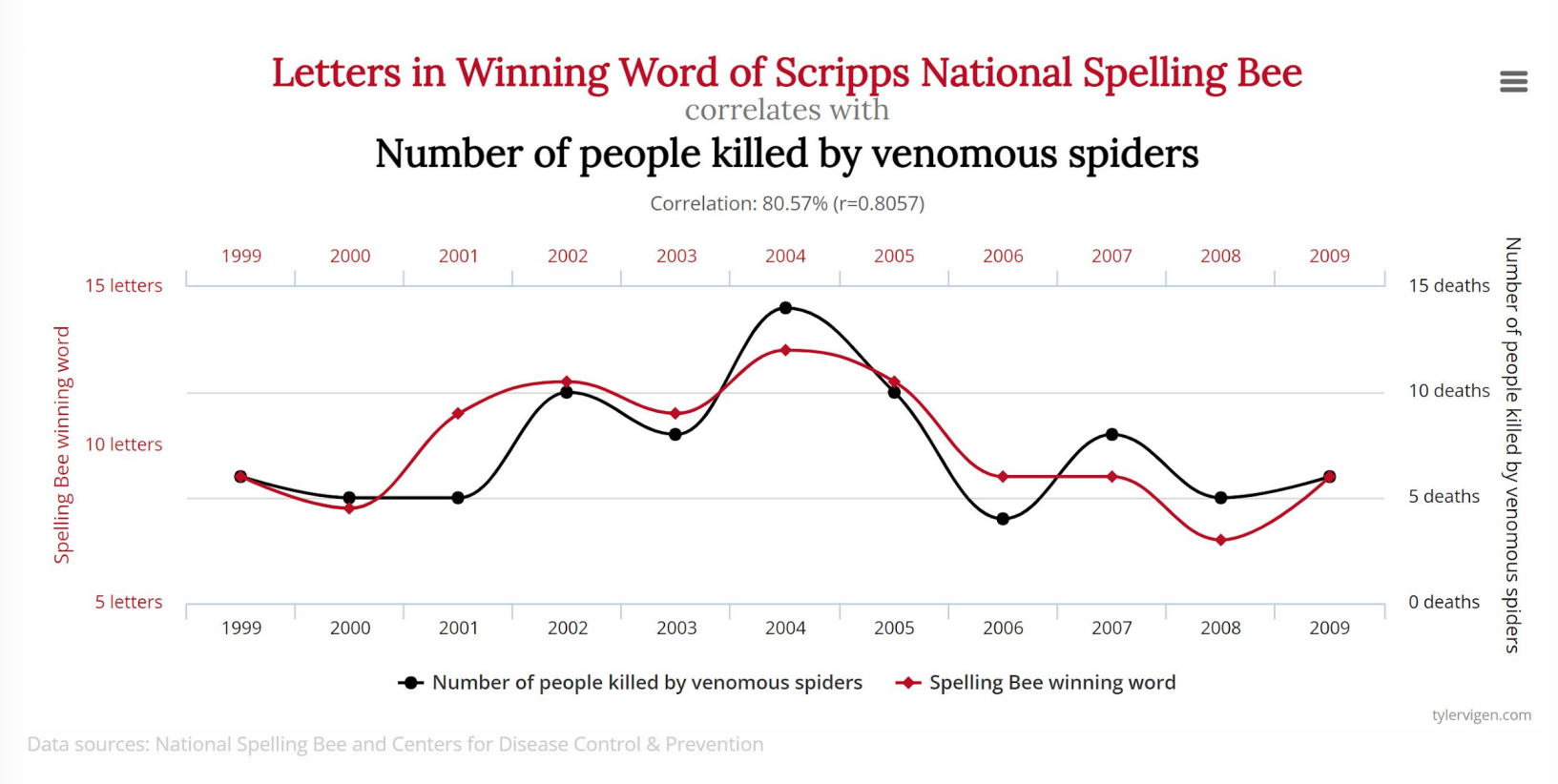
Data interpretation

What hypotheses might be supported by this data?



Correlation

- https://www.tylervigen.com/spurious-correlations



Correlation (or association) does not imply causation!

If there is no correlation that suggests the absence of a casual relationship but the opposite is not true.

Earth: tectonics

Phrasing

- Be wary of multiple choice options with an absolute (like “always”, “all”, “none”, or “never”)
- Stay away from words like “proven” and try instead “supports” “suggests” or “implies”
  - e.g. “The experimental data supports the hypothesis…” not “The hypothesis was proven…”
- Only experiments can determine casual relationships but other types of research can still be useful (including for hypothesis generation)
- Consider the pros and cons of different approaches

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Thank you!